Formatics

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ABSTRACT

The aim of this paper is to elaborate upon certain key aspects of a conceptual framework which we believe helps unpack the sociotechnical and sociomaterial nature of human organisation through the idea of the enactment of significance. In this paper we focus upon unpacking a particular, and surprisingly neglected, aspect of this process of accomplishing significance: that of forma – the 'substance' of a sign. Even though we are surrounded by formative technologies (especially digital computing technologies) in the modern world, we lack a clear understanding of the variety of forma, and the place of forma within various systems that accomplish significance. Therefore, within this paper we consider a number of common principles evident amongst a series of diverse and 'strange' examples of forma. In examining these cases we suggest a number of tentative aspects of what we might call a theory of formatics: an area which considers both the fundamental nature of forma and the place of such forma within the larger universe of communicative and performative accomplishment. We conclude with an examination of the place of formatics within a wider informatics directed at better performatics.

Keywords

Enactment, Significance, Data, Information Technology, Formatics.

INTRODUCTION

This paper introduces aspects from a programme of theoretical work that the author has been engaged in over the last few years. It takes an approach which might be described as 'strange' excursions in the semescape. The content of the paper is deliberately strange in the sense that we are attempting to break down (Bødker and Grønbœk, 1991) a number of established and entrenched conceptions in the 'information' disciplines (Information Management, Information Science, Information Systems, Computer Science). It is an excursion because we deliberately traverse unfamiliar 'terrain', usually in terms of what are interesting but non-standard cases and examples (at least as far as the information disciplines are concerned), but clearly which have relevance to fundamental matters of trans-disciplinary foundation. Finally, we use the term *Semescape* to denote that area at the intersection of signs, patterns and systems with which we are trying to engage, and which we believe has a wider relevance: particularly for a more effective positioning of 'information technology' within the wider context of communicative and performative accomplishment.

In previous work we have suggested that a confusion of terms within the conceptual vocabulary used within the 'information' disciplines holds back progress (Beynon-Davies, 2011): particularly any attempt to demonstrate and communicate the connective, inter-disciplinary nature of an endeavour which seeks to understand the interaction between information, systems and technology. This, as a consequence, further hinders any attempt to develop a meta-discipline which might form a trans-disciplinary core of understanding for such information disciplines.

Some of the contemporary information disciplines, such as Computer Science, have attempted to raise their game by addressing some of this problematic and introducing a new term – *Informatics* – to denote this attempt. However, this term informatics, as currently constituted, is poorly defined. Where it is defined (particularly in the UK) it is defined quite narrowly as an extension of the study computation, particularly to new areas such as biology. We would like to use the term informatics as a placeholder for something larger and more interesting. We use it as an umbrella term to denote a distinct locus at the intersection of the key concerns of the 'information' disciplines. The author has developed a tentative conceptual framework which seeks to unify important insight from this area of intersection; particularly as it concerns a conceptual foundation for such disciplines. The framework also draws upon a number of other areas; many of which are not particularly well-covered within the 'information' disciplines, but which help illuminate aspects of this locus. This paper therefore

introduces aspects of this conceptual framework which we believe helps unpack the sociotechnical (Rose, Jones et al., 2005) and sociomaterial (Orlikowski, 2007) nature of human organisation through the concept of the *enactment of significance*.

However, the key aim of the current paper is to focus upon a particular, and surprisingly neglected, aspect of the enactment of significance: that of forma. Even though we are surrounded by what we refer to as formative technologies in the modern world, we lack a clear understanding of the variety of forma, and the place of forma within various systems that accomplish significance. Therefore, within this paper we want to consider a number of common features (Stamper, 1973) evident amongst diverse examples of forma. In examining these cases we suggest a number of tentative aspects of a theorisation of formatics: a term we use to denote an area which considers the fundamental physical nature of signs and the place of such forma within a larger universe of communicative and performative accomplishment.

In Latin, the term forma denotes form or shape. We adapt this term to suggest the base upon which other facets of our framework are built. Forma relates to the physical and empirics levels of signs – an under-studied branch of semiotics (Eco, 1977). Forma is a fruitful concept because it enables us to do a number of useful things – some of these things help to substantiate, some to illuminate, some to push the boundaries of our conceptual envelope. Part of the reason for considering the nature of forma is that doing so helps us to better understand and to provide greater precision to the concept of data as well as highlighting the many differences between data and information. Because it relates to the physical and technical environment it also gives greater precision to the notion of 'information' technology.

A number of 'strange' examples help explain the value of forma as a concept: all these examples are instances of forma but from vastly different domains. All such examples have a number of core features in common, which we seek to list. We conclude with a thought experiment: are disciplines such as Computer Science, as currently constituted, better thought of as one aspect of a larger field of formatics and how would such a formatics relate to a wider informatics and performatics?

THE VARIETY OF FORMA

There is evidence of symbolic manipulation by humans for at least 50,000 years. Some suggest that representation inherent in symbolism emerged with our species: Homo Sapiens (Marshack, 2003). Homo sapiens (wise man) is also Homo habilis (man the toolmaker). But man is not unique amongst species as a user of tools. Many species of monkey and ape, for instance, have been shown to use simple tools to transform aspects of their world, such as in the use of sticks to dig for termites by chimpanzees. Nevertheless, as a species we do appear unique in the complex ways in which we manipulate signs as 'tools' (Vygotsky, 1986).

Forma therefore seems inherently associated with fundamental aspects of human existence. Genevieve Von Petsinger (Ravilious, 2010), for instance, has identified 26 signs painted on cave walls with a World-wide distribution and dating to the Upper Palaeolithic period (35,000 – 10,000 B.C.). The cave signs are in at least one sense familiar to modern man – they all consist of graphical symbols. But forma is not limited to graphical representation. For example, small clay tokens of multiple shapes and frequently marked in various ways have been found in a variety of sites in the Near East. Dating from the period between 8,000-3,000 B.C the archaeologist Denise Schmandt-Besserat believes that such tokens represent the earliest evidence for explicit and persistent symbols being used to 'account' for things (Schmandt-Bessarat, 1992). When this token system came about, circa 8,000 B.C., the first tokens consisted mainly of abstract shapes formed in clay such as cones, spheres, tetrahedrons, disks, and cylinders. In about 4,400 B.C., what Schmandt-Besserat refers to as *complex tokens* started appearing in the early cities of Sumer. These tokens consisted of new more complex shapes and the use of incised markings. Certain clay tokens were meant to look like what they represented, such as in the case of the token which stood for an amphora of wine. But most clay tokens were patterns in which there is no obvious association between the shape and what it represented. Hence, there is no obvious association between a cylindrical clay token and a domesticated animal. As such, the majority of token types consisted of conventional patterns (Lewis, 2002): signs to which a conventional meaning was clearly assigned by groups of actors.

The rise of techne such as the clay token can be seen as an attempt to compensate for limitations in human psyche, particularly human cognition. In support of cooperative and simple activities between individuals in small communities human memory is sufficient. However, as communities grow in size the complexity of activities also increase. In particular, activities of economic exchange typically take place between strangers and generally are reliant typically on some division of labour. In such circumstances humans invented the externalisation of memory in records. Records compensate for the limitations of individual human memory and extend it into social or collective memory. Records of economic transactions, for instance, institutionalise memory of past economic exchanges and the obligations placed upon individuals engaged in such exchange. Accurate record-keeping is also critical in establishing and sustaining trust between strangers engaging in economic exchange and for supporting social relationships such as ownership and debt.

Michael Hobart and Zachary Schiffman (Hobart and Schiffman, 1998) offer a useful historical perspective on the long-term nature of technologies of information. Although both writing and speech constitute communication and therefore impart information, they limit their definition of the first information age to the invention of writing. In their eyes, writing is seen as the first information technology. However, Schmandt-Besserat and others would argue that writing is actually not the first information technology. Marcia and Robert Ascher (Ascher and Ascher, 1997), for instance, emphasise that writing is actually not a necessary condition for civilisation. Instead, some medium for record-keeping is required. In this regard, take the case of the Inkas, a sophisticated society which existed in the high Andes of South America for a comparatively short time (c.1200–1572 AD). To administer their large empire the Inka maintained a large and sophisticated 'bureaucracy'. This bureaucracy sent and received many messages daily in support of the activity of the empire. Typically such messages contained details of resources such as items required or available in store houses, taxes owed or collected, census data, and the output of mines or the composition of particular workforces. Messages had to be clear, compact and portable. For this purpose a form of artefact known as the *khipu* was used, consisting of an assemblage of coloured, knotted cotton or camelid (llama or alpaca wool) cords.

In the language of the Inka the word khipu means *to knot* and hence specialist personnel known as the khipucamayuq (the keeper of the khipus) were responsible for encoding and decoding messages contained in khipus. Encoding or 'writing' a khipu involved tying together a complex network of cords of different materials and colours, and tying into them a series of different forms of knot. Decoding or 'reading' a khipu involved a khipucamayaq both in visual inspection and running his fingers rapidly over the knots, rather like a Braille reader.

Both the clay token and the khipu are examples of persistent, disembodied forma. But human and non-human actors also communicate using embodied, non-persistent forma. The classic example here is human speech. But communication also occurs on the non-verbal level between human actors through forma such as facial expression. Darwin in *The Expression of the Emotions in Man and Animals* detailed a number of propositions relating to human facial expression. First, he believed that such forma display evidence of the fact that homo sapiens as a species experience a common range of mental states, which we refer to as emotions. Second, such emotions are expressed by a common and shared range of facial expressions. Third, that humans share a range of such emotions and the facial expressions associated with them with the higher apes. Fourth, that the evidence of the universality of emotive expression in humans and their appearance in closely related species demonstrates the evolution of this range of behaviours in man.

In evolutionary terms such forma can be seen to be a development from earlier formative systems employed by Homo Sapiens. Therefore, there appears some basis for inferring that forma is the basis of all communication, including animal communication. In the 1950s and 1960s, for instance, the Austrian ethnologist Karl Von Frisch (von Frisch, 1967) carried out a series of studies which revealed evidence of communication amongst European honeybees. He found that when a honeybee scout discovers a useful source of nectar it flies back to its hive and then performs a dance, observed by other bees. The details of this dance appear to communicate a number of things including the distance to the food source from the hive and the direction of the food source.

There is thus an inherent relationship between forma, actors and action. Prairie dogs, for instance, use a number of different sensory modalities to communicate (Beynon-Davies, 2011a). They communicate through sounds such as alarm calls, through visual signals such as wagging of their tails and standing upright in an alert posture; they also seem to communicate through the use of olfactory and odour cues given off by glands situated both in their anus and in their faces. Alarm calls are by far the most well studied forms of prairie dog communication, particularly amongst Gunnison prairie dogs. The alarm calls comprise loud and often repetitive vocalisations that sound similar to certain forms of bird call. Such calls are given by one or more prairie dogs within a colony when a predator is detected. A particular type of call produces a distinct escape response on the part of other prairie dogs on hearing the call. All five species of prairie dog produce such calls but the acoustic structure of these calls varies between species.

Human emotive facial expressions, the dances of the European Honeybee and the calls of prairie dogs are all examples of non-conventional forma: they are innate rather than learned forms of symbolic expression. However, within much human communication the relationship between forma and meaning is conventional and arbitrary. Handedness is a key feature we share with other primates. Some such as Mithen (Mithen, 2006) suggest that earlier forms of human may have lacked the ability to vocalise – however, they may have communicated with other forms of bodily gesture such as hand gestures. Hand gestures are hence a significant part of human forma. A common hand gesture consists of the open palmed hand which might signal 'stop', the clenched fist 'solidarity', the upturned thumb 'well done', the O sign 'OK', the pointing figure 'look at that' and the v-sign as 'victory' or 'peace'.

Many of the physical sciences are starting to see information as a fundamental property of the universe (Stonier, 1994). Genetics, for instance, for a long time has utilised some fundamental ideas relating to forma such as coding – perhaps forma

encompasses any aspect of signalling – for anything that can act. Deoxyribonucleic acid (DNA) is a nucleic acid that is normally seen as the motor of organisation amongst all known living organisms. Soon after it was discovered, DNA was referred to as a 'code'. In other words, the molecular structure of this acid is generally seen as containing instructions needed to construct other components of cells, such as proteins and RNA molecules.

KEY FEATURES OF FORMA

There seem to be a number of common features evident amongst all the examples we have just discussed. Such features help define the class forma, and are listed below:

- Feature 1:Difference. Forma is about the accomplishment of difference; in fact coherent patterns of such differences.
- Feature 2: Modulation. Differences consist of 'modulated' aspects of matter or energy.
- Feature 3: Pattern. The fundamental formative process – that of coding - amounts to the patterning of forma for the making of messages.
- Feature 4: Actor. Forma cannot be divorced from the notion of an actor perceiving (sensing) and acting (effecting) upon physical patterns.
- Feature 5: Entanglement. The creation and use of forma (forma-tion) is constitutively entangled with in-formation (sense-making/communication) and per-formation (instrumental action).
- Feature 6: Data system. Forma is accomplished within coherent sets of patterns which comprise data systems. The idea of a data system provides a vocabulary for speaking about the structure and dynamics of forma and representing this as a data model.
- Feature 7: Persistence. The term information technology is actually confusing since all 'information technologies' are examples of persistent data systems.

As a tentative premise we would like to propose that all forma can be considered in such terms from human speech, clay tokens, khipu and the dances of the European honeybee. As a consequence of this we would further propose that it might prove useful to denote that specific area of interest in forma and its associated 'technologies' as the meta-discipline of formatics.

FEATURE 1: DIFFERENCE AND DISCRIMINATION

Following Bateson we define forma in very general terms as *any difference that can be used to make a difference* (Bateson, 1972). More accurately we should say that forma constitutes any pattern of physical differences that can be used to make further patterns of physical differences.

A physical environment without evidence of difference conveys nothing. In other words, if the environment within which an organism exists is entirely uniform in nature then it will have no effects upon such organisms. Fortunately, differences are endlessly transmitted around the physical environment. Differences in the surface of an object become differences in the wavelengths of light. Differences in light signals become differences in stimulation on the sensory cells making up the eye of some organism such as a prairie dog. These differences stimulate in turn differences in patterns of activity in the nervous system of the organism which in turn stimulate differences in bodily movement such as posture and locomotion.

Hence, forma is built from base acts of discrimination or distinction by particular actors. The essence of discrimination or difference is being able to 'draw 'a boundary around some thing: some aspect of the physical environment. In doing so an actor distinguishes that which is inside the boundary and hence part of the thing, such as 'it', from that which is outside the boundary and not part of the thing, such as 'me'.

Spencer-Brown symbolises this as O (Spencer-Brown, 1969), where the circle represents the boundary and the act of 'drawing' the boundary amounts to the base act of discrimination; which, it is further argued, may be the base operation of the process of perception/cognition. This is similar to Rosch's base act of categorisation (Rosch, 1973): distinguishing something from something else. It is also interesting that the circle appears to be one of the most common symbols painted on cave walls by our remote ancestors (Ravilious, 2010).

Spencer-Brown's seminal book, *the Laws of Form*, proposes that all forms of experience involve the process of severing a formless space by drawing a distinction in it and then arranging indications or tokens of that distinction (Spencer-Brown, 1969). First then we have a formless space - an original undifferentiated wholeness. Then we draw a distinction within this

space causing it to be severed or taken apart, such as distinguishing me from not-me. Then we represent one of the parts, the distinguished spaces, by a token, such as a personal name.

To summarise: the essential feature of the laws of form (LoF) is the mark symbolised as O. This mark is used to distinguish some thing from everything that is not that thing. Hence, the mark is meant to symbolise the drawing of some distinction or the making of some difference. The counterpoint to the mark is the unmark, symbolised by the absence of the mark. The mark can be interpreted as 1 - the existence of something while the unmark can be interpreted as 0 - the absence of something. Alternatively, the marked state can be interpreted as True – something exists, while the unmarked state can be interpreted as False - something does not exist. LoF has not surprisingly been seen as merely a simpler notation for Boolean Algebra or as providing philosophical underpinning for binary representation in mathematics.

FEATURE 2: THE MODULATION OF MATTER AND ENERGY

The making of some difference implies also making a similarity. Difference and discrimination is hence critical to the concept of modulation which we adapt from that used in signal engineering. Modulation is the process by which variety is introduced into a signal: a measure of the number of possible states or differences a signal can take. If we are unable to modulate the pattern of a signal then no content can be communicated between sender and receiver along a communication channel. Once we can vary the signal then it becomes possible to code certain messages using coherent differences in the signal. Coding is thus the translation of a signal from one formative medium into the same pattern expressed differently in some other formative medium.

Consider the example of a bee that has returned from a foraging trip to the hive. Bees carry with them a pouch of material from the hive which they release as they re-enter. The odour emanating from this pouch indicates to guarding bees at the entrance that they are part of the hive and provides the foraging bee with safe entry. In this example, the foraging bee is the sender and the guarding bee is the receiver of the signal. The content or message is coded as a signal in terms of a pattern of pheromones or odours and transmitted through the air by diffusion. The distinct patterning of pheromones constitutes modulation in this formative medium.

FEATURE 3: THE PATTERNING OF FORMA

Differences and similarities are thus the core elements of patterns. We recognise or identify a pattern when we (as actors) observe a consistent difference repeating or recurring across situations. Or alternatively, we might recognise a pattern as a similar set of differences that replicate over time.

When a forager honeybee returns to the hive her odour signals her identity as a member of the hive. Hence, at the level of forma, we might say that the bee odour is ‘written’ by the forager bee on a particular formative medium and ‘read’ by attending bees along this medium. The odour is clearly a pattern of pheromones which can be used consistently and coherently across situations in which two bees meet to authenticate each other as fellow hive members.

The warning calls of the prairie dog can be considered as consistent patterns of sound produced by the vocal organs of this animal. As a pattern, each prairie dog call consists of between 2-25 separate and individual barks. Such calls are also repeated within larger units known as bouts. Each call can last for as long as thirty minutes and can be heard over a distance of one mile; the intensity of the signal increasing as danger moves closer and only ending when danger has passed.

In the case of clay tokens, differences were signalled mainly through the modulation of the shape of such tokens. The ‘form’ of a given clay token clearly signalled a distinctive pattern for actors in ancient Sumeria. Over the millennia the variety of this sign-system increased with a greater range of modulated forms. Sometimes, for instance, markings were used to extend the range of patterns possible in the formative medium of clay.

FEATURE 4: THE INHERENT ASSOCIATION BETWEEN ACTORS AND FORMA

But what is a formative medium? First, it is some aspect of matter or energy used for communication. Second, such matter or energy must have properties which facilitate the coherent coding of messages through modulation. Third, both the ‘writing’ and ‘reading’ of particular messages rely upon particular sensory modalities available to particular actors (senders and receivers of such messages). It relies upon the sensory and effector apparatus of such actors.

Therefore, forma cannot be divorced from the notion of an actor perceiving (sensing) and acting (effecting) upon physical patterns. The examples we have described previously illustrate the degree of variation in forma across time, human cultures and animal species. Following Sebeok (Sebeok, 1976) we can classify forma in terms of empirics: the type of matter or

energy used to signal something. Theoretically, any form of matter, whether it be solid, gas or liquid, can be used as forma. Likewise any form of chemical or physical energy can be used to provide a signal for communication.

A signal therefore consists of the patterned modulation of energy or matter along some communication channel. For instance, human speech travels as a signal consisting of a pattern of sound waves (acoustic energy through air), while facial expressions rely upon the reflectance and transmission of light (optical, reflected, physical energy). Matter in its various guises as gases, liquids or solids can also be used to build forma. Hence, honeybees can communicate through the transmission of particular odours (gases diffusing through air) and through vibrating honeycomb within the hive (manipulation of a solid). While humans can use complex assemblages of knotted strings (solids) formed from the natural material of camelid (Llama or Alpaca) wool or shapes formed in clay to represent things.

To adapt an idea from communication theory, coding amounts to the process by which a message is represented in some forma (such as a signal of energy) through some pattern. For instance, a pattern made by one of the distinct vocalisations of prairie dog is used when a coyote approaches. Two dominant frequencies are evident in the pattern which is divided into 45 segments of short barks of about one tenth of a second in duration. Hence, prairie dogs learn to re-form consistently vocal patterns which code significance.

Communication theory also demonstrates the centrality of binary coding. As we have seen, the most basic unit of discrimination is binary in nature. Not surprisingly then, Shannon's 'information' or communication theory (Shannon, 1949) is a theory of forma measured in terms of binary differences. Any pattern can theoretically be re-coded as a binary pattern and Shannon uses this to measure the degree of orderliness in a signal and from this to infer the degree of significance encoded.

FEATURE 5: THE ENTANGLEMENT OF FORMATION, IN-FORMATION AND PER-FORMATION

Therefore, following Peirce, Spencer-Brown and others we cannot conceive of forma without the notion of an actor 'forming'. Signs relate for some actor the symbol which stands for some referent: something that is referred to. We deliberately use the term actor here rather than person because we wish to focus on the issue of how signs are used by actors in action. An actor is any entity that can act and thus includes humans, animals and machines. Amongst the range of acts that an actor can typically undertake is a range of what we shall call formative acts. They may also engage in informative and performative acts: acts of communication and coordinated, instrumental activity. In evolutionary terms, formative acts are first embodied acts, reliant upon sensory modalities which in turn rely upon the sensory and effector apparatus of actors.

The concept of forma can be seen to be reliant upon two concepts familiar in ethology: the study of animal behaviour - the sensory modalities and associated sensory apparatus of particular communicative actors. Take the case of the honeybee. The honeybee relies primarily on four key sensory modalities for communication: smell, sight, taste and touch. There is also some evidence that honeybees have a form of hearing and an undefined ability to sense the Earth's magnetic field.

Honeybees, like most insects, have compound eyes made up of some 4500 individual light sensors known as ommatidia. These eyes produce images of relatively low resolution as compared to humans but enable them to sense a fairly broad range of colour. Although bees do not see red, they can differentiate between six major categories of colour, including yellow, blue-green, blue, violet, and ultraviolet. They also see a colour known as 'bee's purple': a mixture of yellow and ultraviolet. Honeybees taste, smell and touch using their antennae which are covered with odour and taste receptors. Hence, they have been found to be able to distinguish between sweet, sour, bitter and salt 'tastes'. They also use their antennae to gauge the width and depth of cells while constructing honeycomb. There is evidence for them communicating via both touch and 'hearing' during bee dances. Sounds are received by attending bees through organs located on the legs and on antennae.

Forma takes its place as an inherent part of the accomplishment of significance. Forma is necessarily entangled with two other patterns of organisation or order: with informa and performa. Such patterns constitute three different but inter-dependent forms of action enacted by actors. Performa enacts forma which enacts informa and in turn enacts performa. It is through this continuous cycling of action that significance is accomplished.

Take, for example, the waggle dance of the honeybee in this light. A honeybee that has found a food source performs a number of actions on returning to the hive. Key aspects of this performa enact forma in the sense that these intensions serve to represent intentions. Hence, the degree of excitation in the straight part of a so-called 'waggle dance' is taken to stand for the quantity of some food source. The quantity of the food source thus represents the informa attempting to be communicated by one bee to another. This informa, in turn, if successful, stimulates performa in attending bees: they leave the hive in the direction of the food source. On their return to the hive they are likely to construct a further cycle of significance.

The sign-system of prairie dog alarm calls is also continually enacted in such a cycle of forma, informa and performa. The sensory apparatus of this higher organism is attuned to certain natural signs within its environment. The visual apparatus of the prairie dog in particular is well-developed for spotting the presence of predators within the colony space. As natural forma, the presence of such predators acts as a stimulus for the formulation of some intention or mental state about the state of the immediate environment. Such an intention causes the prairie dog to formulate an intension which it wishes to communicate. Through its effector apparatus the prairie dog forms an appropriate warning call. As embodied forma such a call serves to encode various principles of the identified animal – particularly the type of predator. Other prairie dogs within the vicinity of the call 'read' such forma from the auditory sensory modality. They in-form, by matching elements of the call with aspects from their own memory. This stimulus therefore serves to open up an appropriate response – some appropriate performance - on the part of the receiving actor; such as diving down the nearest burrow.

For our purposes, it is important to distinguish between three distinct types of forma in terms of the source of signalling: natural, embodied and disembodied or persistent forma. Forma produced from the natural environment signal natural signs. Natural signs signify what Searle (Searle, 1995) refers to as brute facts. Hence, objects in the external environment of some actor are continuously signalling their properties and can be picked up by sensors within the sensory apparatus of such an actor. Hence, a prairie dog on alert will sense the movement of a predator such as a coyote within distance of sight of a colony. Changes enacted by the actor using its effector apparatus will signal to other actors and hence also act as forma. Hence, a honeybee might move its body in various ways within distinct forms of 'dance' or a human might make particular facial expressions. This is what we mean by embodied forma in the sense that the forma is reliant on some form of immediate bodily action on the part of the actor. Finally, actors may produce artefacts which are given independent existence beyond the body. Such artefacts can hence persist beyond any one communication and can signal to multiple actors sometimes remote in time and space. This is what we mean by disembodied or persistent forma. Large assemblages of coloured and knotted cord known as Khipu are key examples of such disembodied forma. Such artefacts then achieved an independent existence of the actors creating them and could persist in the sense that they could be transported through time and space by other actors.

FEATURE 6: DATA SYSTEMS AND DATA MODELS

Forma clearly do not exist in isolated units, but work within larger systems which we might, following Newell and Simon (Newell and Simon, 1976), refer to as physical symbol systems. A physical symbol system consists of physical patterns (symbols) which can be combined into structures and manipulated to produce new structures. We prefer to denote this with the term data system and suggest a particular interest in those data systems in which the symbols have some persistence. By persistence we mean that symbols exist for some duration over and above the communication within which the symbols were used.

We need some way of unpacking at a meta-level the structure of forma and the way such forma are used within transformation. For this we turn to the idea of a data model (Tsitchizris and Lochovsky, 1982) from database theory. Within such theory a data model is an abstraction of the key principles of some database - a formal language for representing, organising and manipulating data.

Any data model can be seen to consist of two types of inter-dependent constructs: representors and operators. Representors amount to the static side of a data system and are primitives of data representation or organisation – they indicate the format necessary to code patterns. Operators amount to the dynamic side of a data system, exercised through data processing.

In terms of data representation, a data model can be described at a high level of abstraction in terms of a hierarchy of data items, data elements and data structures. A data item or datum is the lowest-level of data organisation, corresponding roughly to the concept of a symbol. A data element is a logical collection of data items and a data structure is a logical collection of data elements. Hence, for example, from traditional database theory, within the relational data model (Codd, 1970) the data structure is the relation which is composed in turn of tuples or rows (data elements). Each row is composed of a number of attributes or columns (data items) which store values.

Data processing can be seen to be built from a number of core types or classes of formative act from which all forms of such processing can theoretically be built: create, read, update and delete. Create or 'write' actions involve creating new data structures or representing new data elements within data structures (¬<d>). Update actions involve changing the value of data items in the sense that the symbols appropriate to the data item are changed (↓<d>). Delete actions involve removing data elements from data structures (¬<d>). Retrieval or 'read' actions involve accessing data from data items, data elements and data structures (↑<d>).

Actors only 'read' natural forma; they have no part to play in the creation of such forma or in updating or deleting such forma. In contrast, within types of embodied forma actors can both 'write' and 'read' such forma. They can 'write' to a

particular sensory modality using parts of their effector apparatus and 'read' from a sensory modality using associated parts of their sensory apparatus. Within types of persistent forma actors normally perform all four types of core formative act: 'write', 'read', 'update' and 'delete'. In other words, persistent forma allow the greatest range of formative actions.

Therefore, Khipucamayuq engaged in all four types of formative act in relation to khipu. For instance, a create formative act might consist of constructing a pendant cord with its associated knot group and tying this cord to the main cord (⌐<pendant cord>). In contrast, an update act might involve changing the configuration of a particular knot group upon the pendant cord (↓<pendant cord: knot group>), perhaps by changing the position of one knot upon the pendant cord.

Within ancient Sumeria, actors 'modelled' the storage and distribution of commodities through the creation and deletion of clay tokens and clay envelopes. Hence, creating a clay token and packing this in a clay envelope might be used to represent the commitment of a certain group of commodities by certain actors to the central surplus of the city-state. Such a clay token might be destroyed or discarded when such commodities were distributed at some later time.

FEATURE 7: THE UBIQUITY OF PERSISTENT DATA SYSTEMS

To summarise: formative acts do not occur in isolation; they form patterns. We denote the organisation of such patterning as a data system. Data systems occur at the level of forma and are systems of physical symbols. Data systems consist of recurring patterns of formative acts and such patterns consist of the repeated application of particular operators on particular representors. We find that the idea of forma, and particularly the idea of persistent forma, extremely useful as a means of providing greater precision to the idea of 'information' technology. It will come as no surprise to find that we prefer to refer to it as data or formative technology – because information or informa is subtly different from but entangled with data or forma.

As we have seen, the concept of embodiment is potentially useful in defining the special class of forma we refer to as techne or technology. Anything produced solely and directly by the body is not techne but may be artefactual. Human speech is an artefact, a creation, reliant on the innovation of human spoken language. However, speech requires the body for its production, and solely the body. Writing or written language is however techne. To produce writing one typically uses the body but one augments this use through tools, whether such tools be clay and stylus, threads of llama or alpaca wool, or keyboard and computer screen. The artefact becomes disembodied (Derrida, 1971) and takes on a life of its own independent of the actor that created it.

This is why we have used the terms writing and reading forma in a flexible and perhaps non-standard way. In terms of embodied forma it is appropriate to speak of 'writing' to a particular sensory modality such as the auditory channel by one actor and 'reading' from this channel by another actor. But data technology truly emerges with the innovation in writing and reading persistent forma.

Unfortunately, the term writing tends to be associated with a particular class of persistent forma which some have referred to as sound writing – where signs relate to units of speech. Sound writing interposes a spoken linguistic unit between a sign and its concept or referent. There is however an earlier and simpler form of writing which has been referred to as thought writing – where there is a direct relationship between a sign and its concept or referent. Hence, writing, or more accurately sound writing, is not the only data technology. Clay tokens and khipu are equally significant examples of data technology.

Within modern digital computing technology a distinction is frequently made between structured data, typically in the form of records and unstructured data such as text, audio and video – which demands a particular form-at. This distinction is designed particularly to distinguish data amenable to storage and manipulation in a database from that which is difficult to store and manipulate in such terms. Further, structured data is described in terms of a data model whereas unstructured data lacks a clear data model. From the previous discussion it should be apparent that we believe that this distinction is artificial. All forma by its very nature has structure and as a consequence can be described by some data model. Hence, human speech can be decomposed into phonemes, phonemes composed into words and words linked in phrases and sentences. A human facial expression can be decomposed into specific muscle movements of the face linked in combination. The dance of the honeybee can be decomposed into specific movements.

CONCLUSION

Computer science is clearly founded in the study of computation – particularly computation using digital computing technology. The modern computer is the formative technology par excellence of the modern age. But perhaps it should not be seen as a revolution but as an evolution from earlier and simpler formative technologies. A modern digital computer 'computes' by performing logical operations with physical forma, based in the application of semi-conductors and electro-

magnetic radiation. But perhaps we might say that computer science, as currently constituted, is only part of a larger study of forma.

Perhaps there are sufficient grounds to consider denoting this larger study of forma and its associated 'technologies' – of which the modern digital computer is the most prominent and dominant – as formatics. In a sense, the idea of computation as formulated in that of a Turing machine (Copeland, 2004) and perhaps instantiated within biological patterns such as genes and physical patterns such as atomic particles (Wegrzyn, 2001) – really exemplifies this. This will allow us at least to broaden the study of representation and operation and perhaps offer distinctive, trans-disciplinary lessons for newer formative technologies such as quantum or biological (DNA) computers (Kari, 2001).

However, a key lesson we draw from the analysis above is that a proper rendering of formatics cannot be achieved without an appropriate understanding of the informatics and performatics relevant to particular examples of the enactment of significance. To take a particularly interesting example, the formatics of human emotive facial expression is sufficiently well understood to make it possible for such forma to be reproduced by software and robotics. The appropriate application of such forma within social settings however relies on appreciative understanding of the ways in which facial expression is used within the wider range of human communicative competency. It also relies upon an appreciation of the uses to which facial expressions are put within human coordinated action. Any design of formative technology for facial expression must therefore be in-formed by substantive communicative competence and directed at appropriate per-formance.

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